COMPARISON OF THE KIP MANEUVER AT THE HORIZONTAL BAR BETWEEN THE SKILLED AND UNSKILLED SUBJECTS

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The purpose of this study was to investigate differences in the joint kinetics of the kip maneuver of the horizontal bar between ten skilled and three unskilled subjects. The kip maneuvers were videotaped with a VTR camera to obtain biomechanical data by a motion analysis technique. Kinematic characteristics of the skilled subjects were the straight body position and longer distance between the CG and the bar during the forward swing. The shoulder joint torque power of the skilled subjects under the bar was larger than that of the unskilled ones. The peak of the hip flexion power of the skilled subjects was later than that of the unskilled ones. The results suggested that the timing of motion is essential in the kip maneuver, and that the unskilled subjects should emphasize the hip flexion in later timing after the reversal point.

KEY WORDS: kip, horizontal bar, motion analysis, joint torque.

INTRODUCTION: The kip at the horizontal bar is one of the important skills in gymnastics, which is difficult for beginners to learn and execute. Most of the investigations on the kip compared successful trials with failed ones and the execution of the skilled subjects with that of the unskilled ones, using kinematic parameters. Although only a few researchers have investigated the joint torque and the mechanical energy during the kip maneuver (Bauer, 1983; Hatze, 1995), they did not compare techniques of the skilled and the unskilled subjects. To develop the technique of the unskilled subject, it is essential to investigate not only kinematic differences between the skilled and unskilled subjects but also the kinetic differences. The purpose of this study was to investigate differences in joint kinetics in the kip maneuver at the horizontal bar between the skilled and unskilled subjects.

METHODS: Ten varsity club gymnasts (age, 19.5±1.2 yrs; height, 1.67±0.03 m; body mass, 60.2±3.0 kg) performed the kip maneuver at the horizontal bar as skilled subjects. Their maneuver in the sagittal plane was videotaped with a VTR camera (60Hz). Three male subjects (age, 27.0±2.6 yrs; height 1.76±0.02 m; body mass, 70.6±11.2 kg) who had no experience to perform the kip maneuver were selected as the unskilled subjects. However, they participated in technical training for 5-12 days to learn the kip maneuver. Although all trials of the unskilled subjects were videotaped (60Hz) during technical training, the first successful trial was analyzed as the unskilled kip maneuver. The kip maneuver is not so impactive and is done smoothly. Therefore, we think the sampling frequency of 60 Hz was enough to analyze the kip maneuver and to compute the torque and the power of the joints. Eleven body landmarks (elbow, shoulder, toe, heel, ankle, knee, greater trochanter, vertex, tragion, suprasternale, and lower end of thorax) and the center of the bar were digitized. The coordinates were smoothed with a fourth order Butterworth digital filter with cut-off frequencies ranging from 3 to 6 Hz which were determined automatically by the technique of Wells and Winter (1980). The net joint torque of the shoulder and the hip was calculated using an inverse dynamics approach. Inertia parameters of the subjects were estimated from the body segment parameters after Ae (1996). The joint torque power was calculated as a product of the joint angular velocity and the joint torque. Kinematic and kinetic parameters for the period of motion were normalized by the time from the instant that the CG passed just under the bar during the forward swing to the equivalent instant during the backward swing, i.e. 0% and 100%, respectively.

RESULTS: Figure 1 shows the sequences of the kip maneuver for the skilled and a typical unskilled subject, drawn in every 10 percents. The skilled subjects kept the straight body position until 40%, flexed the hip joint until 90%, and extended the shoulder and the hip joints around 130%. On the other hand, the unskilled subject began the shoulder extension and the hip flexion around 0% and then the hip extension around 70%. Both subjects rotated forward

in the similar maneuver after 120%. Therefore the comparison suggests that there was a remarkable difference in the early period between the skilled and the unskilled subjects.

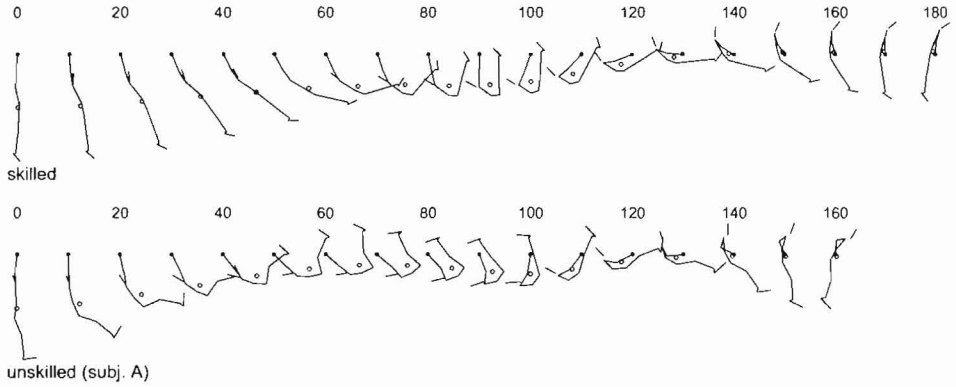

Figure 1. Sequences of the skilled and the unskilled (subj. A) kip maneuver draw in every 10 percents. The skilled kip maneuver was normalized by time and the subject's body height and averaged using the standard motion construction technique by Ae, et al. (1997).

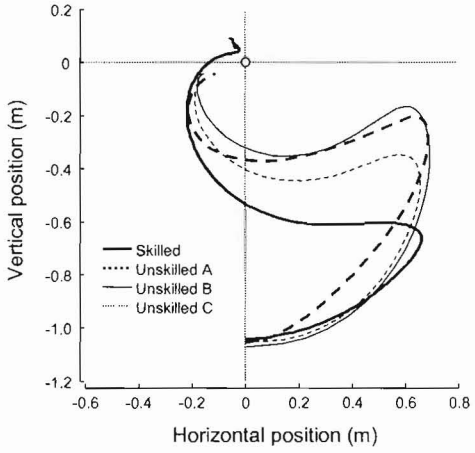

Figure 2. The CG trajectories of the skilled and the unskilled subjects.

Figure 2 shows the CG trajectories of the skilled and the unskilled subjects. The reversal point, where the direction of the swing was changed, was lower in the skilled subjects than that of the unskilled subjects. The CGs of the unskilled subjects were dropped after passing the reversal point, then were raised again. Bauer(1983) reported with a one mass model of the kip that a gymnast should shorten the distance between the CG and the bar around the reversal point and the point under the bar during the backward swing to increase the mechanical energy. The skilled subjects began to shorten the distance between the CG and the bar from

the reversal point, while in the unskilled subjects it was from the instant that the CG passed under the bar during the forward swing. Figure 3 shows the angular velocity, joint torque, and joint torque power of the shoulder and hip joints for the skilled and the unskilled subjects. The peak angular velocity of the shoulder extension of the skilled subjects was larger than that of the unskilled ones. Although the peak angular velocity of the hip extension and the flexion were similar in both subject groups, the patterns of the hip flexion velocity were remarkably different: The peak flexion velocity for the skilled subjects appeared in the second half of the forward swing, but that of the unskilled ones was seen at the instant of 0%. The shoulder extension torque was exerted in almost the whole phase of motion in both groups. The skilled subjects showed a peak of the shoulder extension torque around 90% while the unskilled ones showed a few peaks between 20% and 100%. The hip flexion torque of the skilled subjects was exerted later than that of the unskilled ones. Although the shoulder and the hip joint torque powers were positive in almost the whole phase of motion, the shoulder joint torque power of the skilled subjects under the bar was remarkably larger than that of the unskilled ones. There were two peaks in the hip joint torque powers of both subjects. The first peak of the hip flexion power of the skilled subjects was later than that of the unskilled ones.

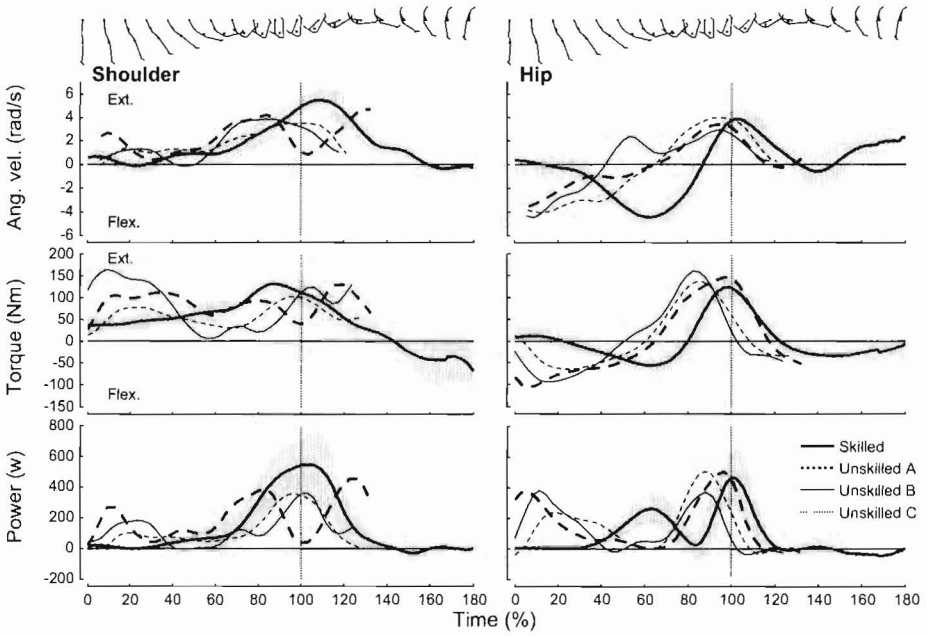

Figure 3. The change in the shoulder and the hip joint angular velocity, joint torque, and joint torque power for the skilled and the unskilled subjects.

DISCUSSION: Kinematic characteristics of the skilled subjects were the straight body position and longer distance between the CG and the bar during the forward swing. These will provide an advantage for the skilled subjects as it does not raise the CG in early timing during the forward swing. The lower reversal point shown by the skilled subjects might give us the impression that their range of the swing was small. The skilled subjects began to extend the shoulder joint and to flex the hip joint later than the unskilled ones. Therefore, the joint flexion/extension period of the skilled subjects was shorter than that of the unskilled ones. The skilled subjects exerted large shoulder joint torque and extension velocity under the bar, while the unskilled subjects exerted the shoulder joint torque in the earlier period when the joint angular velocity was small. These differences in the timing of joint torque exertion and angular velocity should explain the major difference in the performance of the kip maneuver

between the skilled and unskilled subjects. This finding will also suggest the importance of the proper timing of joint motions in the kip, which would be induced from the straight body position and the larger CG distance, as mentioned above.

CONCLUSIONS: The comparison of the kip maneuver between the skilled and the unskilled subjects revealed the following differences: a) the difference in the timing to begin the flexion of the hip joint, b) the differences in the shoulder joint torque power and the timing to exert the hip flexion torque. The results suggested that the unskilled subjects should emphasize the hip flexion in later timing after the reversal point.

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